

INSTRUCTIONS FOR ALNOR TYPE 7000 DEW POINTER



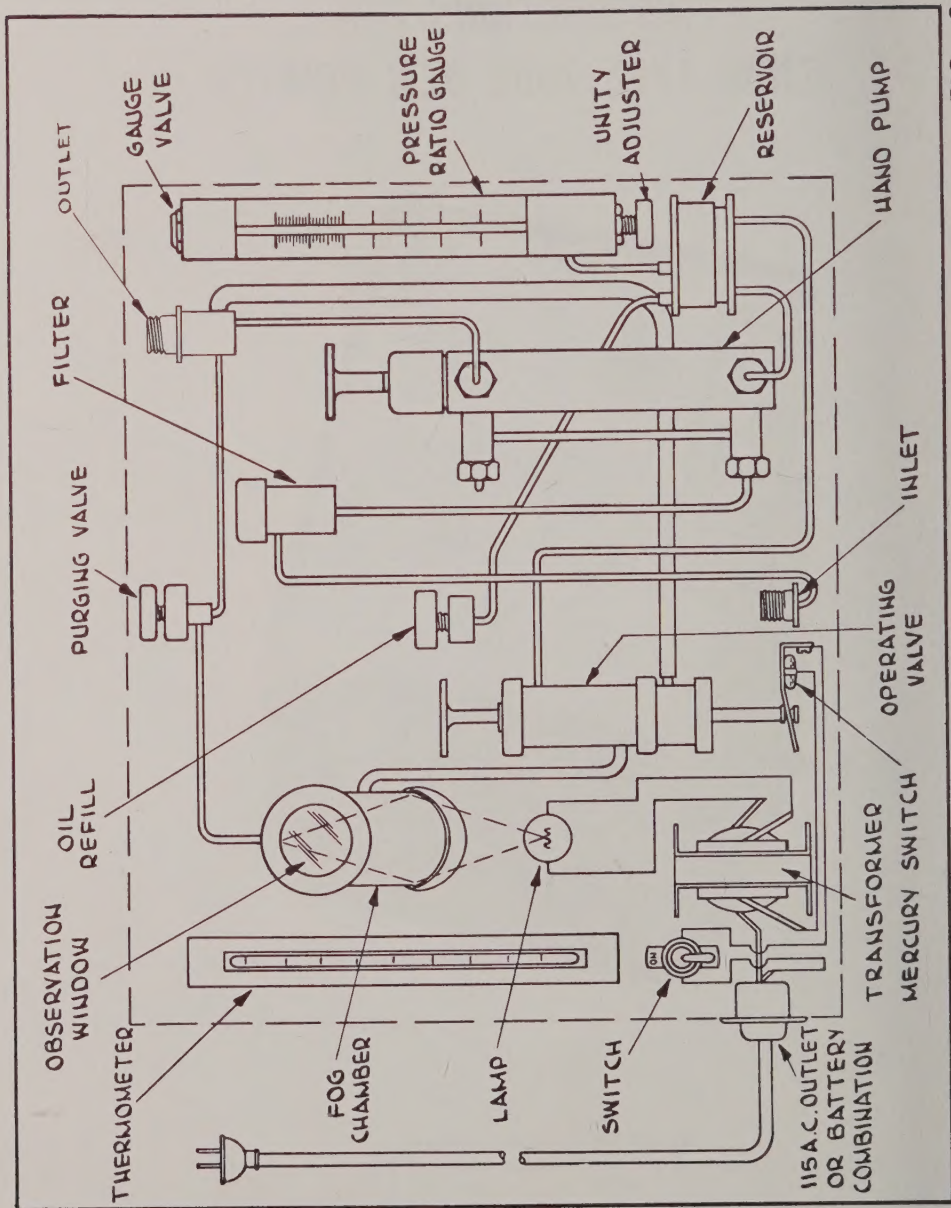
ALNOR INSTRUMENT COMPANY
Division of Illinois Testing Laboratories, Inc.
420 N. La Salle Street
Chicago, Illinois 60610
Area Code 312 467-1331

INSTRUCTIONS FOR ALNOR TYPE 7000 DEW POINTER



FIG. 1

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SCHEMATIC DIAGRAM

INSTRUCTIONS FOR "ALNOR" TYPE 7000 DEW POINTERS

Introduction

The Alnor Dew Pointer is used to determine the dew point of a gas-water vapor mixture. When a gas-water vapor mixture is cooled there is some temperature at which water will begin to condense out. By definition this temperature is known as "Dew Point".

As a sample of a gas-water vapor mixture is cooled its relative humidity is increased. If the sample is cooled sufficiently the relative humidity will reach 100% — i.e. the sample will be "saturated". Any further cooling will result in the precipitation of water. Therefore the saturation temperature and the dew point temperature are identical values.

Dew Point is a convenient way of determining and expressing the absolute humidity of air and other gases.

The 7000 instrument is available in three nominal dew point ranges as follows:

TYPE	NOMINAL DEW POINT RANGE
7000H	Room Temp. to - 20°F.
7000U	Room Temp. to - 80°F.
7000L	0°F. to - 80°F.

The actual range of each instrument is dependent on the temperature of the Dew Pointer and the gas being tested in addition to the range of the pressure ratio gauge.

The convenience, portability, accuracy, reproducibility (several different operators can easily get the same results) and freedom from the use of external coolant, make the instrument highly desirable.

Connections

If A.C. power is to be used connect the Dew Pointer to a convenient 50 or 60 cycle source of the voltage indicated on the name plate by means of the cable provided.

Connect the source of gas to the inlet (bottom center) of the meter. Copper connecting tubing is most desirable (sweat the copper tubing to the fitting supplied), although a dense neoprene tubing may be used for dew points above -20 F. Ordinary rubber tubing may cause large errors. **All Connections Must Be Tight.**

If the source of gas is at a pressure appreciably above atmospheric pressure a shut off valve should be provided in the inlet line.

The outlet of the Dew Pointer (rear) may be connected to a suitable waste line if desired.

Adjustments

Before operating the Dew Pointer, a Unity Adjustment must be made on the Pressure Ratio Gauge as follows:

1. Place operating valve in out position.
2. Open Purging Valve to be sure there is no pressure in the instrument.
3. Depress the Gauge Valve and turn the Unity Adjuster until the bottom of the meniscus is in line with the 1 mark.
4. Release the Gauge Valve.

Close the purging valve and pump up the instrument until the pressure ratio gauge reads about .5. Open the purging valve. If the meniscus does not return to the 1 mark after a few moments, repeat the unity adjustment as above. It sometimes happens that after a period of prolonged idleness the flexible diaphragm in the oil reservoir takes a set, but the above operation will correct the condition.

If the source of gas is above atmospheric pressure be sure to shut off the source of pressure before making the unity adjustment.

WARNING: Never depress the gauge valve unless the operating valve is out and the purging valve open, and the supply valve closed.

The unity adjustment should be checked frequently—particularly if the instrument temperature or barometer pressure is fluctuating.

Operation

Open the purging valve. Pull out the operating valve. Turn the switch to "ON".

Place switch in "A.C." or "B" (for battery) according to the power source to be used.

Pump the gas to be tested thru the instrument to flush out all the old gas in the Dew Pointer (at least 10 to 15 strokes of the pump). When very low dew points are to be tested more thorough purging is required. The Dew Pointer will give the correct dew point of the sample in the instrument. Be sure to flow enough gas thru so that the gas in the instrument is the gas you want to test.

When the gas is generated under pressure, permit this pressure to force the gas

thru the instrument to perform the purging operation, and minimize the pumping.

Close the purging valve. Pump a sample of gas in the instrument. Look into the observation window and press down on the operating valve.

Depressing the operating valve actually performs three operations in the following sequence.

1. Closes line from the inlet and pressure ratio gauge.
2. Turns on the light.
3. Rapidly opens the line from fog chamber to the atmosphere.

If a fog (cone of sunbeams) appears, it indicates the gas was cooled below the dew point and subsequent trials should be made at lower pressures (numerically higher pressure ratios). Make similar trials at each higher major division on the pressure ratio gauge until one reading is obtained where no fog appears. Then "Close In" on the end point, i.e. maximum pressure ratio that will produce a fog.

The object of the operation of the Dew Pointer is to determine the pressure ratio that will just produce a fog. This is called the "End Point".

If on the first trial no fog appears, it indicates that the gas was not cooled down to the dew point. It is apparent, therefore, that a lower pressure ratio (higher pressure) is required to produce sufficient cooling to reach the dew point. Subsequent trials should, therefore, be made at each lower (higher pressure) major division on the Pressure Ratio Gauge until one trial is obtained in which a fog appears. Having located one point where there is a fog and one where there is no fog, "close in" on the end point. It is easily possible to get the difference between the appearance and non-appearance of the fog to be only .01 apart, as read on the pressure ratio gauge.

After any trial in which a fog appears, it is advisable to take several strokes on the pump to purge the fog chamber of any droplets of moisture that fail to re-evaporate promptly.

When making the last trials near end point, permit 10 to 15 seconds to lapse after pumping the sample into the instrument before pushing down the operating

valve to permit the sample to come to the temperature of the fog chamber.

The experienced operator will find he can determine the end point after a few trials since the density of the fog on any given trial is a valuable clue to how far he is from the end point.

If the approximate value of the dew point is known, the reverse operation of the Dew Point Calculator will indicate the approximate Pressure Ratio which should be used for the initial trial. This will further reduce the number of trials required to achieve the end point.

After determining the end point, take the mean between the minimum pressure ratio that fails to produce a fog and the maximum pressure ratio that produces a fog. Use this value with the initial temperature as read on the thermometer and the Q value for the gas being tested to compute the dew point with the "Alnor" Dew Point Calculator.

Q Values

The Q value of a gas is a natural constant of the gas. It is representative of the cooling power of the gas.

The Q value of the gas being tested must be known to arrive at the dew point of the gas. Values of common gases are given below.

TABLE 1

		Q
Air		.285
Argon	A	.400
Carbon Dioxide	CO ₂	.225
Carbon Monoxide	CO	.285
Dissociated Ammonia		.285
Endothermic		.285
Ethane		.165
Exothermic		.285
Helium	He	.400
Hydrogen	H ₂	.285
Methane	CH ₄	.240
Nitrogen	N ₂	.285
Oxygen	O ₂	.285
Propane		.139

Other Gases

Refer to chemical
Handbooks

Gas Mixtures

Refer to the Appendix.

Use Of The Dew Point Calculator

To use the Dew Point Calculator the following values must be known

1. Q value of the gas.
2. The initial temperature of the gas as read on the thermometer on the Dew Pointer.
3. The pressure ratio required to just produce a fog.

If the Q value is .2855 proceed as follows:

1. Set the arrow "2" opposite the pressure ratio on scale "D".
2. Opposite the initial temperature on scale "F" read the Dewpoint temperature on scale "E".

NOTE: All temperatures are in degrees Fahrenheit.

EXAMPLE: Air is being tested so the Q value is .2855. The thermometer reads 75° F. A fog appears at a pressure ratio of .46, but does not appear at .47, therefore, the end point is .465.

1. Set the arrow "2" opposite .465 on scale "D".
2. Opposite 75 in scale "F"; read the dewpoint temperature of -29.5° F. on the scale "E".

If the Q value is not .2855 proceed as follows:

1. Set the arrow "1" opposite the pressure ratio on Scale "A".
2. Opposite the Q value (Scale "C") read the "Equivalent Pressure Ratio" on Scale "B".
3. Set the arrow "2" opposite the "Equivalent Pressure Ratio" on Scale "D".
4. Opposite the initial temperature (Scale "F") read the dewpoint temperature on Scale "E".

EXAMPLE: Pure methane is being tested. The Q value is .24. The initial temperature is 80° F. A fog appears at .51 but does not appear at .52 so the end point is .515.

1. Set the arrow "1" opposite .515 (Scale "A").
2. Opposite .24 (Scale "C") read the equivalent pressure ratio of .57 on Scale "B".
3. Set the arrow "2" opposite .57 on Scale "D".
4. Opposite 80° F. on Scale "F" read the dewpoint of 0° F. on Scale "E".

Principle Of Operation

The principle of operation of the Dew Pointer is fundamental and simple. A thorough understanding of this principle will aid in the operation of the instrument.

The gas to be tested is pumped into the observation chamber at some pressure above atmospheric. The chamber is then rapidly exhausted to the atmosphere with a resultant expansion and cooling of the gas. If the cooling is sufficient to reduce the temperature of the gas to, or below, the dew point, water vapor will condense out in the form of a fine mist or fog. This fog is readily observable thru the observation window. Because of a light located below

the fog chamber focused at the top of the chamber, the fog appears as a cone of sunbeams.

Successive trials will determine the minimum initial pressure which will produce a fog. The gas is then being cooled just to the dewpoint. The final temperature after expansion (the dew point) which is maintained for too brief an interval to measure, is then computed by means of the equation for an adiabatic expansion. The expansion is adiabatic (no heat added or subtracted during the process) because it is so rapid.

The following equation expresses a fundamental relationship between the pres-

sure and temperature during an adiabatic expansion.

$$\text{Final Temp.} = \text{Initial Temp.} \left[\frac{\text{Final Pressure}}{\text{Initial Pressure}} \right]^{\frac{K-1}{K}}$$

where all values are in absolute units and

$$K = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$$

For the "Alnor" Dew Pointer, the final temperature is the dew point temperature ($t_{D.P.}$). The ratio (P.R.) between the final pressure and initial pressure can be read directly on the pressure ratio gauge without necessity of knowing the individual quantities. By definition $Q = \frac{K-1}{K}$

The equation for an adiabatic expansion can, therefore, be converted into the following form for our purpose

$$t_{D.P.} = (t_i + 460) (P.R.)^Q - 460$$

when the temperatures are in $^{\circ}\text{F}$.

Since the initial temperature (t_i) is read on the thermometer, P. R. is read on the pressure ratio gauge, and Q is a constant that depends on the gas being tested, it is apparent that the solution for the dew point temperature ($t_{D.P.}$) is perfectly straightforward though somewhat cumbersome. In actual use, a calculator is supplied that makes the above computation extremely simple.

The formation of a visible fog at the dew point temperature depends on the presence of dust in the gas to act as nuclei around which the droplets can form. In practically all cases dust is present. If, however, gas is completely dust free (such as gas produced by fractional distillation) it would be possible to cool the gas below the dewpoint temperature without condensing the moisture, if some substitute for the dust particles were not provided. All ALNOR Dew Pointers are therefore equipped with a strip of radium foil built into the fog chamber. The Radium ionizes the gas in the chamber and the ions act as nuclei around which the droplets can form and build up to visible size. These Dew Pointers will, therefore, give the correct result regardless of the presence or absence of dust.

Operating Notes

1. When working with dry gases having low dew points, it should be remembered that extremely small quantities of water vapor are involved. It should further be remembered that the instrument can only give the result for the gas sample that is actually in the fog chamber. It is for this reason that it is extremely important that

the gas does not pick up or lose moisture in the process of being transferred from its source to the fog chamber.

2. Copper tubing is the most satisfactory material for connecting the instrument to the source of gas because it is not hygroscopic. The use of rubber tubing will almost certainly contaminate the gas sample. A dense neoprene tubing is satisfactory except for very dry gases.

It is for the same reason that the filter material should be replaced occasionally.

If an appreciable quantity of dust is allowed to accumulate in the filter, the moisture content of the gas may be altered as it passes through the filter.

3. The built in hand pump is double acting. The gas flowing on the top side of the piston is discharged through the outlet without flowing through the fog chamber.

4. The only function of this gas is to keep the pump barrel dry and avoid contamination of the test gas.

5. Thorough initial purging of the instrument is important. Reference to the vapor density curves (figs. 7 & 8) show that the vapor density at 50°F . is .59 lbs. per 1000 cu. ft. and the vapor density at -70°F . is only .0019 lbs. per 1000 cu. ft. If the instrument were originally filled with air having a dew point of 50°F . and only .1% of the original volume were left in the chamber due to inadequate purging the instrument would give an indication that was 3° high when testing a sample of gas having a dew point of -70°F .

6. It is, of course, important to have all connections tight on the inlet side of the instrument. In some cases momentary negative pressures can be caused in the inlet line by the operation of the hand pump. If there were a leak in the inlet line atmospheric air could flow in and add moisture to the sample during these short periods of negative pressure. Furthermore, the vapor pressure of the air is generally higher than the vapor pressure of the gas being tested. It is, therefore, possible for water vapor to flow in through a leaky connection even when the gas pressure is above atmospheric.

7. If the gas is drawn from a high pressure, as from a bottle of compressed gas, a pressure reading valve or a needle valve will be needed ahead of the Dew Pointer. A connecting line of adequate

size is needed ($\frac{1}{4}$ " copper tubing is suggested). Do not use capillary tubing. Do not use an extremely high rate of flow during purging. The use of an excessive flow rate or the use of capillary tubing may cause moisture to be removed from the gas before it enters the Dew Pointer.

8. The above caution does not imply that the flow rate during purging is extremely critical. If the flow rate is such that the oil in the pressure ratio gauge is between .95 and .98 it will be quite satisfactory.

9. The flow rate must, of course, be great enough to back up the hand pump. The pumping action should not pull an appreciable vacuum on the inlet line.

10. Notice that there is a by-pass around

the fog chamber thru the top side of the pump. If there is pressure on the inlet side of the Dew Pointer it is quite normal to have a continuous flow from the instrument.

11. If a hazardous or noxious gas is being used it is permissible to connect a discharge line to the outlet of the Dew Pointer. It should be of ample size so that the pressure at the outlet is essentially atmospheric. Do not use a gas that will attack brass or copper.

12. A sample may be drawn from a furnace if the dewpoint of the sample is lower than the temperature of the Dew Pointer. A $\frac{1}{4}$ " O.D. Inconel tube is suggested for sampling in a furnace. A five foot soft copper extension will aid in cooling the sample.

RADIO-ACTIVE CONTENT

The legislatures of some of our states have passed bills to protect the people within their states from the indiscriminate use of radio-active materials. In general, these laws require that every piece of equipment containing any radio-active substance, however small, be marked with a distinctive symbol by the owner or user. (time pieces excepted)

Also some of the legislatures have required that each piece of equipment be registered with the State.

In order to facilitate the compliance with these laws in the states where they do exist, we are including the specified symbols in the form of decals and are providing the information which most of the present laws are requesting.

The amount of radio-active material in this instrument is so small that no hazard exists under any conceivable circumstances. This has been ascertained by certified radiological tests.

DATA

1 - Fixed source, sealed, containing 6-1/4 microcuries radium foil.

Q Value Of Mixtures

A mixture of gases can be treated as a single gas if the proper constants are established. The value of Q can be computed by one of the following methods.

METHOD 1-MASS BASIS

Since the effect that the specific heat of an individual gas has on the specific heat of the mixture is proportional to the mass of the gas present the following equation can be written.

$$(1) C_{pm} = \frac{M_x}{M_m} C_{px} + \frac{M_y}{M_m} C_{py} + \dots + \frac{M_z}{M_m} C_{pz}$$

$$(2) C_{vm} = \frac{M_x}{M_m} C_{vx} + \frac{M_y}{M_m} C_{vy} + \dots + \frac{M_z}{M_m} C_{vz}$$

Where

C_{pm} = Specific heat at constant pressure of the mixtures

C_{vm} = specific heat at constant volume of the mixture

C_{vx} , C_{vy} , & C_{vz} = specific heat at constant volume of each gas.

C_{px} , C_{py} , & C_{pz} = specific heat at constant pressure of each gas.

M_m = total weight of the mixture

M_x , M_y & M_z = weight of each gas

Specific heats are expressed in heat units per weight unit per temperature unit such as B.T.U. per pound per °F.

Then

$$(3) K_m = \frac{C_{pm}}{C_{vm}}$$

and

$$(4) Q_m = \frac{K_m - 1}{K_m} \text{ or from figure 3}$$

where

K_m = K value for the mixture

Q_m = Q value for the mixture

It is only necessary to insert the proper values in equations (1) and (2) and then solve.

EXAMPLE FOR METHOD 1

A mixture of gas is known to be composed of the following:

20% by weight CH_4

40% by weight CO_2

40% by weight N_2

Find the value of Q

Substituting in equations 1 and 2

$$C_{pm} = .2 (.593) + .4 (.200) + .4 (.247) = .2974$$

$$C_{vm} = .2 (.450) + .4 (.155) + .4 (.176) = .2244$$

Then

$$K_m = \frac{.2974}{.2244} = 1.337$$

and

$$Q_m = \frac{.337}{1.337} = .252$$

METHOD 2 - VOLUMETRIC BASIS

When a mixture of gases is analyzed with an Orsat apparatus the percentages of each component are determined on a volumetric basis. It is, therefore, essential that these volumetric percentages be converted to weight percentages before Method 1 can be used.

$$(5) \frac{M_x}{M_m} = \frac{X d_x}{d_m} \quad \frac{M_y}{M_m} = \frac{Y d_y}{d_m}; \text{ etc.}$$

where

X = percent by volume of gas X

d_x = density of gas X

d_m = density of the mixture

Notice that any condition of temperature and pressure and any units of density can be used provided the same conditions and units are used thruout.

Equations 1, 2, 3, & 5 can be combined

and multiplied by $\frac{d_m}{d_m}$ to following simple form.

$$(6) K_m = \frac{X d_x C_{px} + Y d_y C_{py} + \dots + Z d_z C_{pz}}{X d_x C_{vx} + Y d_y C_{vy} + \dots + Z d_z C_{vz}}$$

Where X, Y and Z are volumetric percentages of each gas and d_x , d_y , and d_z are the density of each gas.

Since the values of $d_x C_{px}$ are presented in Table 4 the solution of Equation 6 is extremely simple. Q can be obtained from Figure 3. Because of similarity of values CO , O_2 , H_2 , and N_2 , can be considered one gas.

K TO Q CONVERSION CURVE

FIG. 3

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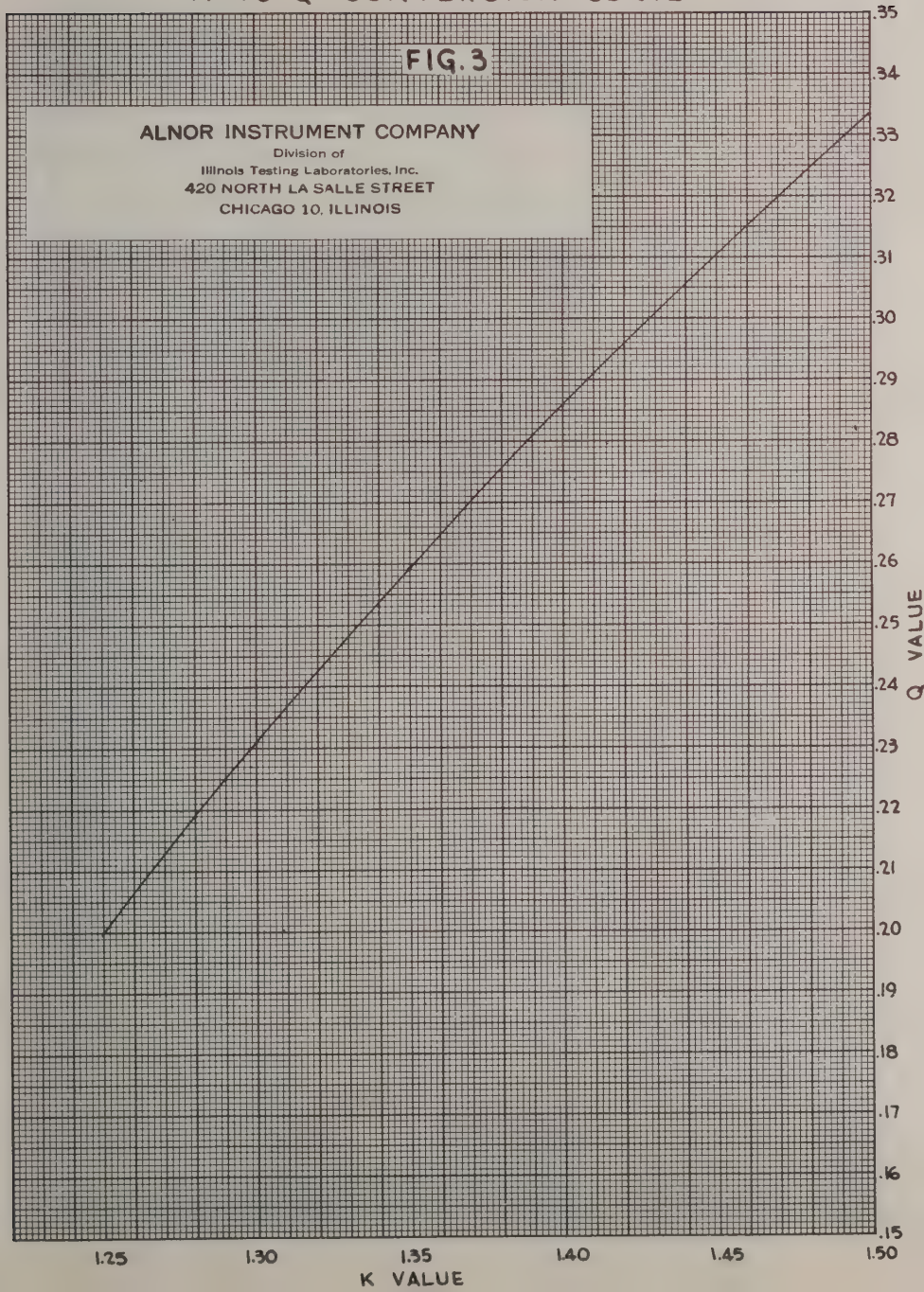


TABLE 4

Gas	Density lbs./c.f. @62°F.	C_p B.T.U. per lb.	C_v B.T.U. per lb.	(d) C_p B.T.U. per c.f.	(d) C_v B.T.U. per c.f.	K	Q
CO	.0735	.245	.175	.0180	.0128	1.40	.2855
N ₂	.0737	.247	.176	.0182	.0130	1.40	.2855
O ₂	.0840	.217	.155	.0182	.0130	1.40	.2855
Air	.0757	.241	.171	.0182	.0130	1.40	.2855
H ₂	.00529	3.42	2.44	.0181	.0129	1.40	.2855
CO ₂	.1156	.200	.155	.0231	.0179	1.29	.225
CH ₄	.0421	.593	.450	.0250	.0190	1.315	.240
He	.01114	1.25	.7530	.0139	.0084	1.660	.400
A	.11135	.125	.0751	.0139	.0084	1.668	.400

Notice that all diatomic gases listed can be treated as a single gas for all practical purposes.

EXAMPLE FOR METHOD 2

A mixture of gases is known to consist of the following:

72% by volume N₂

10% by volume of CO

5% by volume of CO₂

12.5% by volume of H₂

.5% by volume CH₄

Find the value of Q

Substituting in equation 6

Gas	Numerator	Denominator
N ₂	.72 (.0182) = .01310	.72 (.0130) = .00936
CO	.10 (.0180) = .00180	.10 (.0128) = .00128
CO ₂	.05 (.0231) = .00116	.05 (.0179) = .00090
H ₂	.125 (.0181) = .00226	.125 (.0129) = .00161
CH ₄	.005 (.0250) = .00013	.005 (.0190) = .00010
	.01845	.01325

$$K_m = \frac{.01843}{.01325} = 1.392 \quad Q_m = .281$$

METHOD 3-CURVES

A great many commonly used mixtures primarily consist of only one gas other than diatomic gases. For these mixtures values of Q can be picked off of the curves in Figure 4.

The curves in Figure 4 are plotted for mixtures which consist of percentages of the gas named where the balance of the mixture is N₂, O₂, H₂ or CO. If small percentages of other gases are present, they can be ignored.

EXAMPLE-METHOD 3

Given the mixture specified for the example of Method 2 find the value of Q by use of Figure 4.

Since the values of d (C_p) and d (C_v) are so nearly equal for all the diatomic gases assume that they are actually one gas having the characteristics of N₂. Since the volume of CH₄ is small add it to the CO₂ for this purpose, then the analysis of the gas becomes

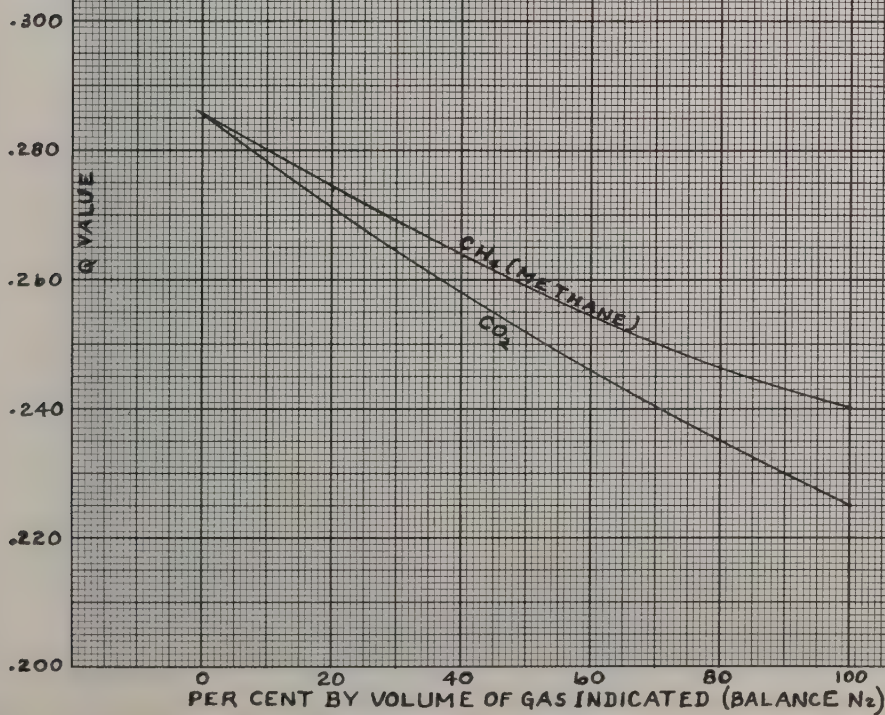
5.5% by volume CO₂

94.5% by volume N₂

From Figure 4 Q = .281

FIG. 4

Q VALUE OF GAS MIXTURES



ACCURACY OF GAS ANALYSIS

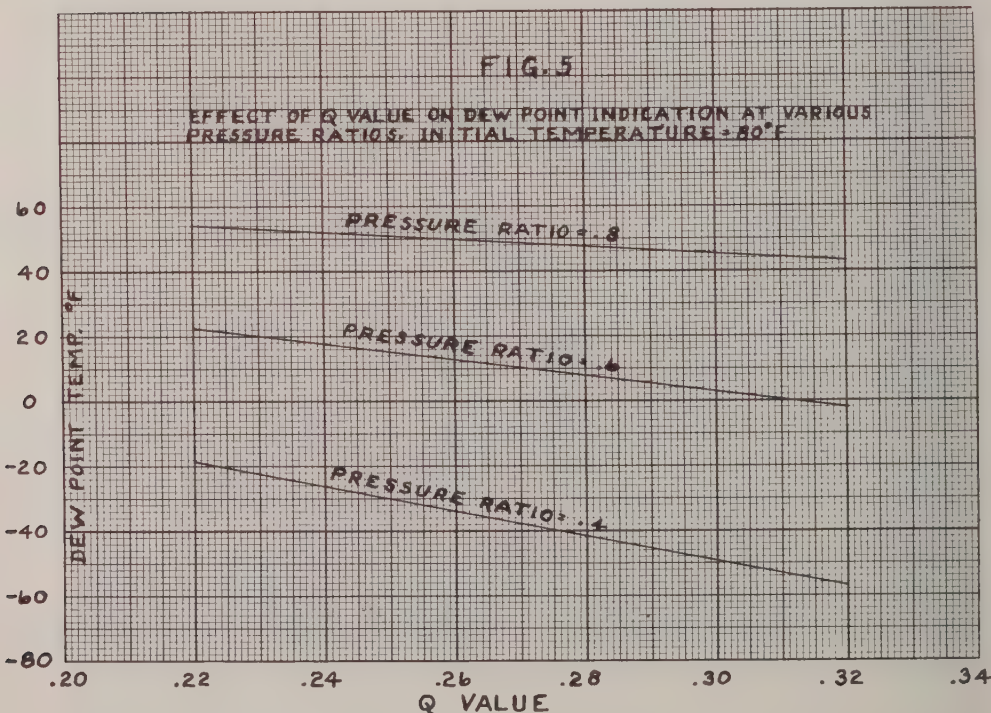
An error of .005 in the Q value will produce an error of approximately 2° F. when the pressure ratio is .4; the error will be less for higher pressure ratios. It is, therefore, apparent an error of about 10% in the volumetric analysis of CH_4 or about 7% in the volumetric analysis of CO_2 is generally permissible. It is, therefore, evident that the "Alnor" Dew Pointer is not dependent upon an accurate gas analysis as far as common mixtures are concerned. It is obviously not necessary to make an Orsat analysis prior to each dew point test.

Figure 5 graphically shows the effect of Q value in the dew point determination assuming an initial temperature of 80° F. For comparatively high dew points (above 0° F.) this value is far from critical. For lower dew points the value of Q should be known with greater accuracy.

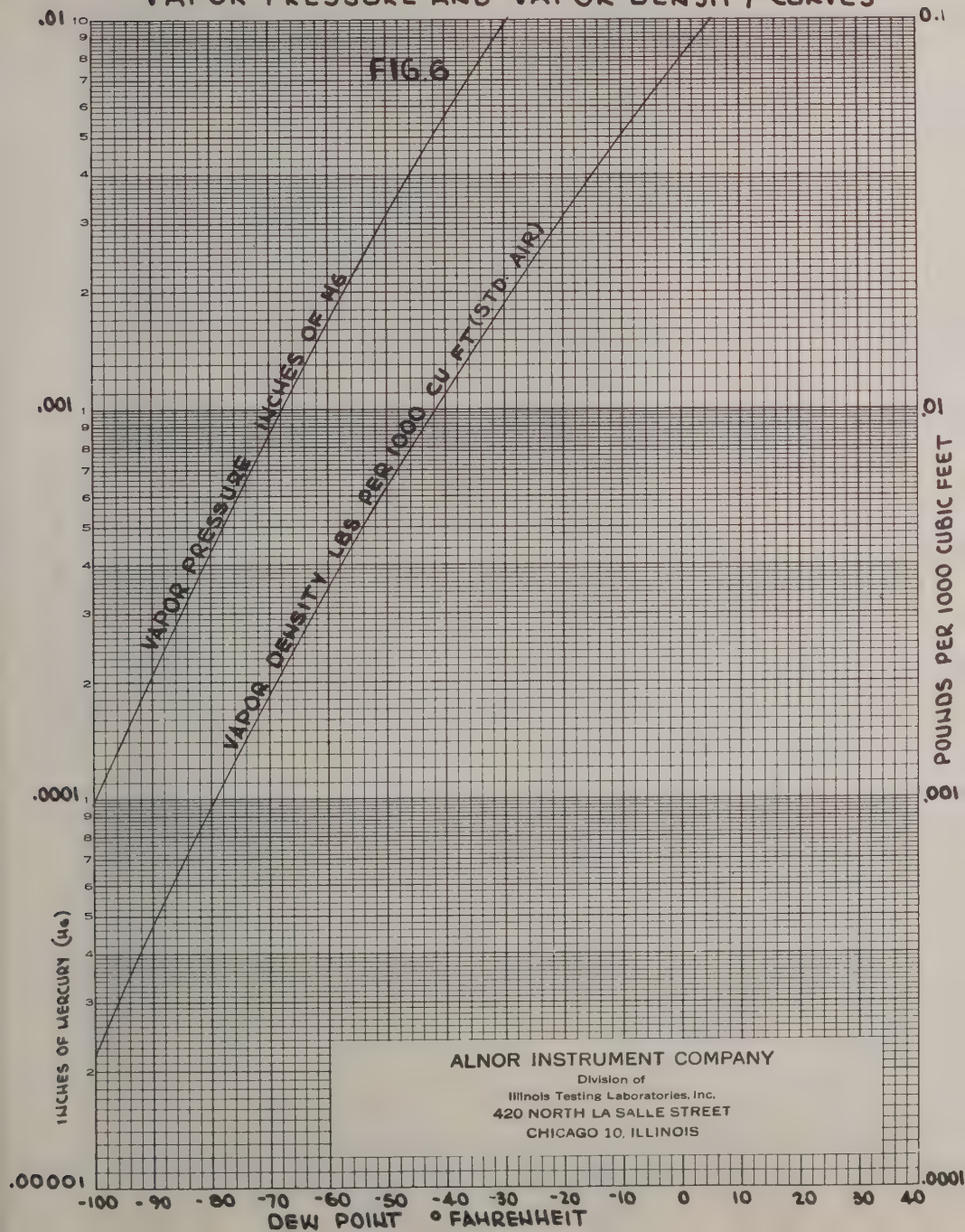
VAPOR DENSITY AND VAPOR PRESSURE

For each dew point there is a corresponding water vapor pressure and water vapor density. The "Alnor" Dew Pointer might just as well have been named a "Vapor Pressure Tester" or "Vapor Density Gauge". The following curves have been provided to permit easy transfer from one set of values to another as the need arises.

For dew points below freezing there are theoretically two possible values for vapor pressure, that is, vapor pressure over ice or vapor pressure over water. There is considerable experimental evidence indicating that the vapor pressure of air corresponds with the vapor pressure of sub-cooled water, whether the air is actually in contact with sub-cooled water or with ice. Accordingly the vapor pressures plotted on the following curves correspond with the vapor pressures over sub-cooled water. Vapor densities are plotted on the same basis.

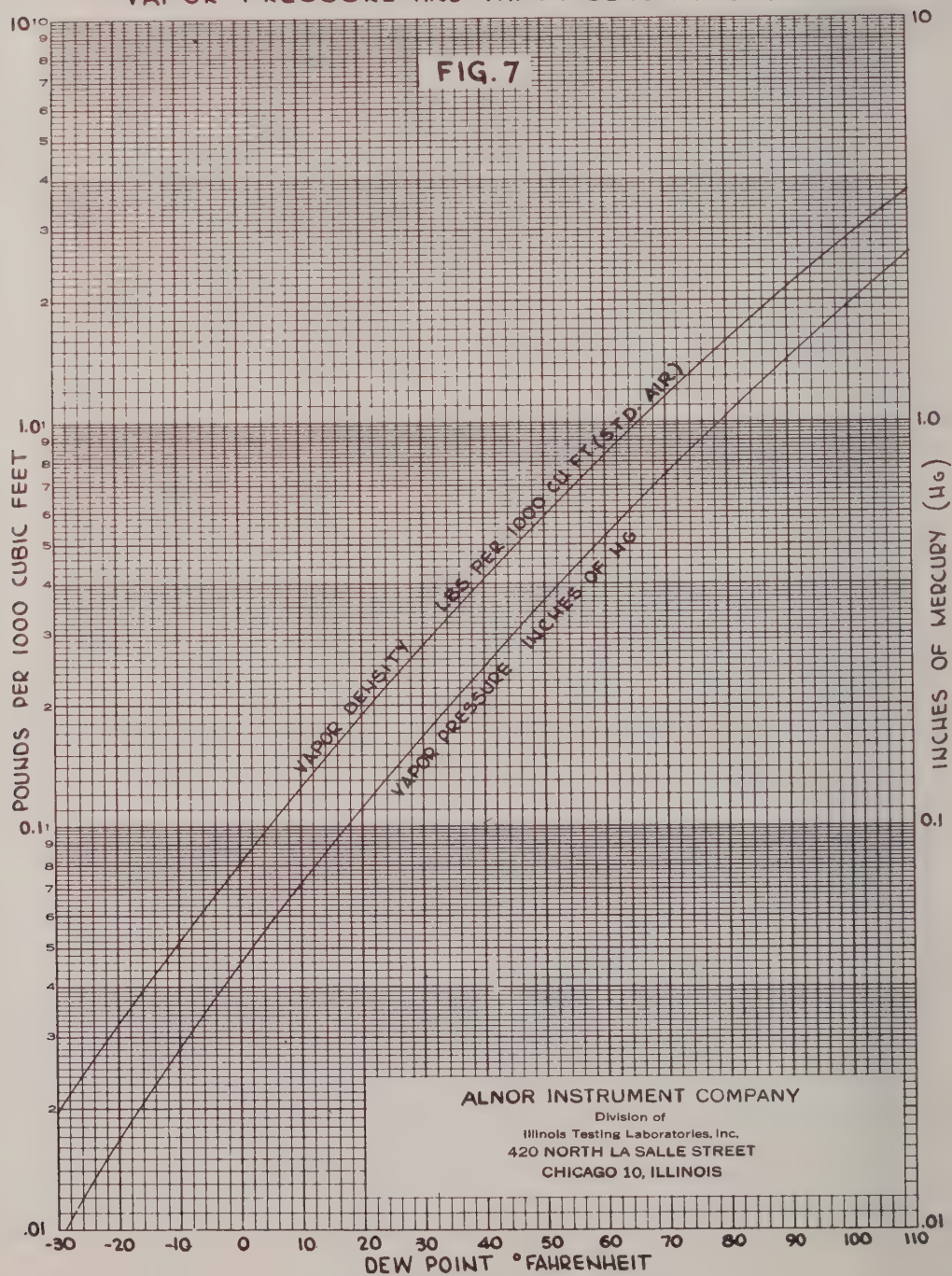


VAPOR PRESSURE AND VAPOR DENSITY CURVES



VAPOR PRESSURE AND VAPOR DENSITY CURVES

FIG. 7



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THE DEW POINTER AS A "GO, NO-GO GAUGE"

For shop use it is frequently desirable to use the Dew Pointer as a Go, No-Go Gauge. In this case the operation of the instrument becomes so simple that comparatively unskilled workmen can use it.

As an example assume a situation where a gas having a Q value of .2855 is carried in a pipeline at 1 pound gauge pressure. The process is to be operated so that the dew point is kept below 0° F. By performing the operations in reverse order the Dew Point Calculator can be used to develop a chart as follows:

1. Set the initial temperature opposite the critical Dew Point Temperature.
2. Opposite the arrow under (2) read the pressure ratio.

FOR 0° F. DEW POINT

Q .2855

Thermometer	Pressure Ratio Gauge
70	.61
72	.60
74	.59
76	.583
78	.577
80	.57

The instrument can be left connected to the gas line continuously with the purge valve cracked so that a small amount of gas is bleeding thru continuously. Thus no additional purging would be required. All the operator would have to do is read the thermometer-close the purging valve-pump the instrument up to the indicated pressure ratio-pause for fifteen seconds-and press the operating valve. If a fog appears the dew point is above 0° F.

DEW POINTS AT ELEVATED PRESSURES

If a sample of gas is compressed it is apparent the vapor pressure is increased. The compressed gas, therefore, has a higher dew point that corresponds to the new vapor pressure.

The "Alnor" Dew Pointer gives the dew point at atmospheric pressure. When the

corresponding dew point at higher pressures is required refer to Figure 8.

Example: A gas is carried in a pipe line at 585 pound gauge pressure. The "Alnor" Dew Pointer indicates the dew point is -65° F. What is the actual dew point in the pipe line.

Answer is 1° F.

PSYCHROMETRIC CHART

Figure 9 shows the relationship between dew point temperatures, dry bulb temperatures, and relative humidity in the low humidity regions which are difficult to read on the usual psychrometric chart. The "Alnor" Dew Pointer is particularly useful for making humidity measurements in this comparatively dry region.

Relative humidity is by definition the ratio of the actual vapor pressure of water vapor (the saturated vapor pressure at the dew point) in an air-vapor mixture to its saturated vapor pressure at the dry bulb temperature.

Relative humidity may also be defined as ratio of the weight of water vapor in one cubic foot of the mixture as indicated by its dew point, to the weight of water vapor in one cubic foot of a saturated mixture at the dry bulb temperature.

Example: Dry Bulb Temperature 80° F.
Dew Point Temperature 0° F.

What is the Relative Humidity?

Answer from Figure 9 4.4%

Figure 10 is a standard Psychrometric Chart. In addition to dew point temperatures, dry bulb temperatures and relative humidity, it shows wet bulb temperatures, grains of water vapor per cubic foot, grains of water vapor per pound of dry air and the volume of the mixture in cubic feet of mixture per pound of dry air.

Example: Dry Bulb Temperature 90° F.
Dew Point Temperature 50° F.

What other values can be read from the Psychrometric Chart?

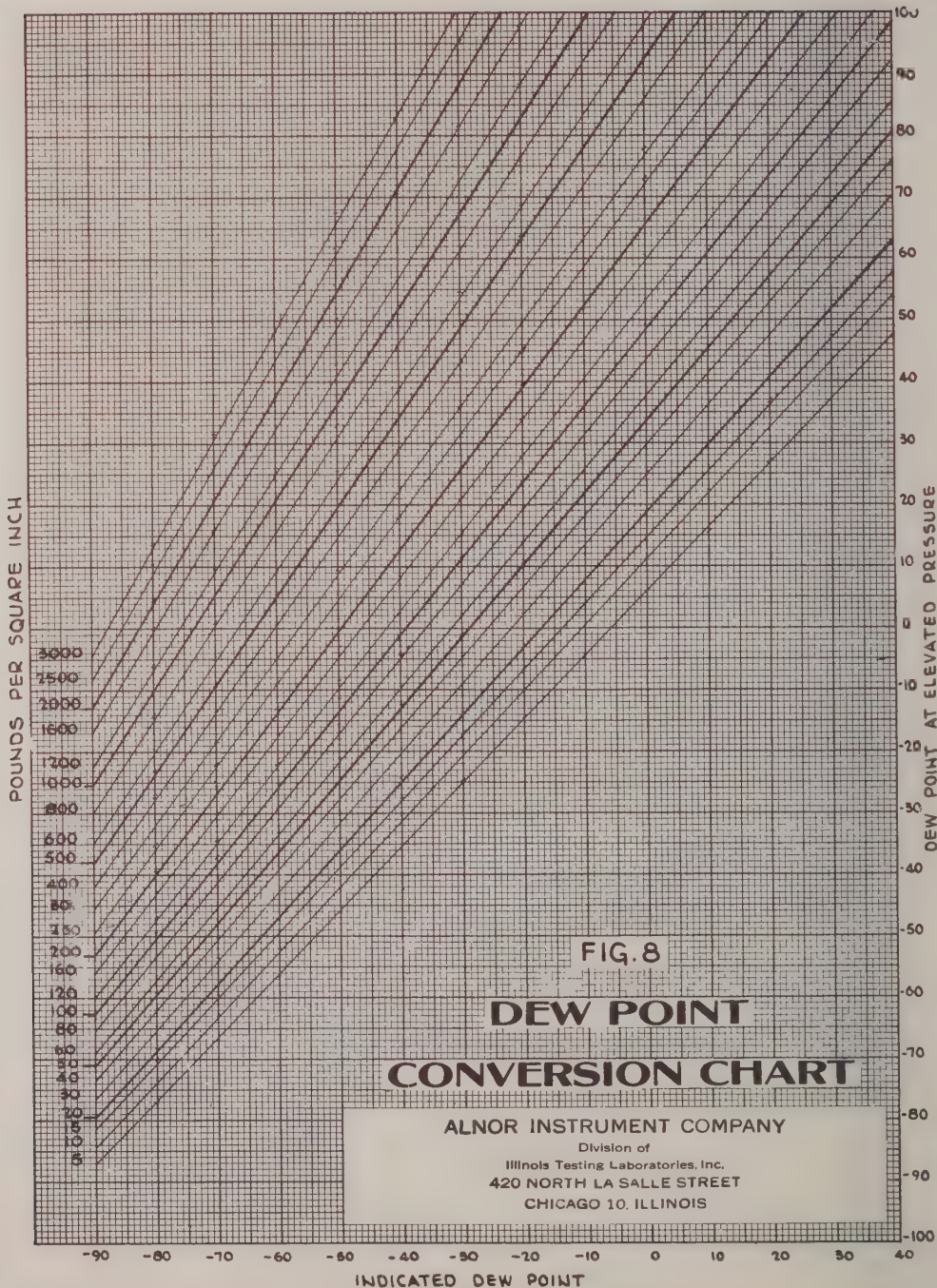
Answer: Wet Bulb Temperature 65° F.

Relative Humidity 25%.

Volume of the Mixture 14.0
per cu. ft. of dry air.

Density of the vapor 4.11
grains per cu. ft.

Weight of the vapor 53.4
grains per lb. of dry air.

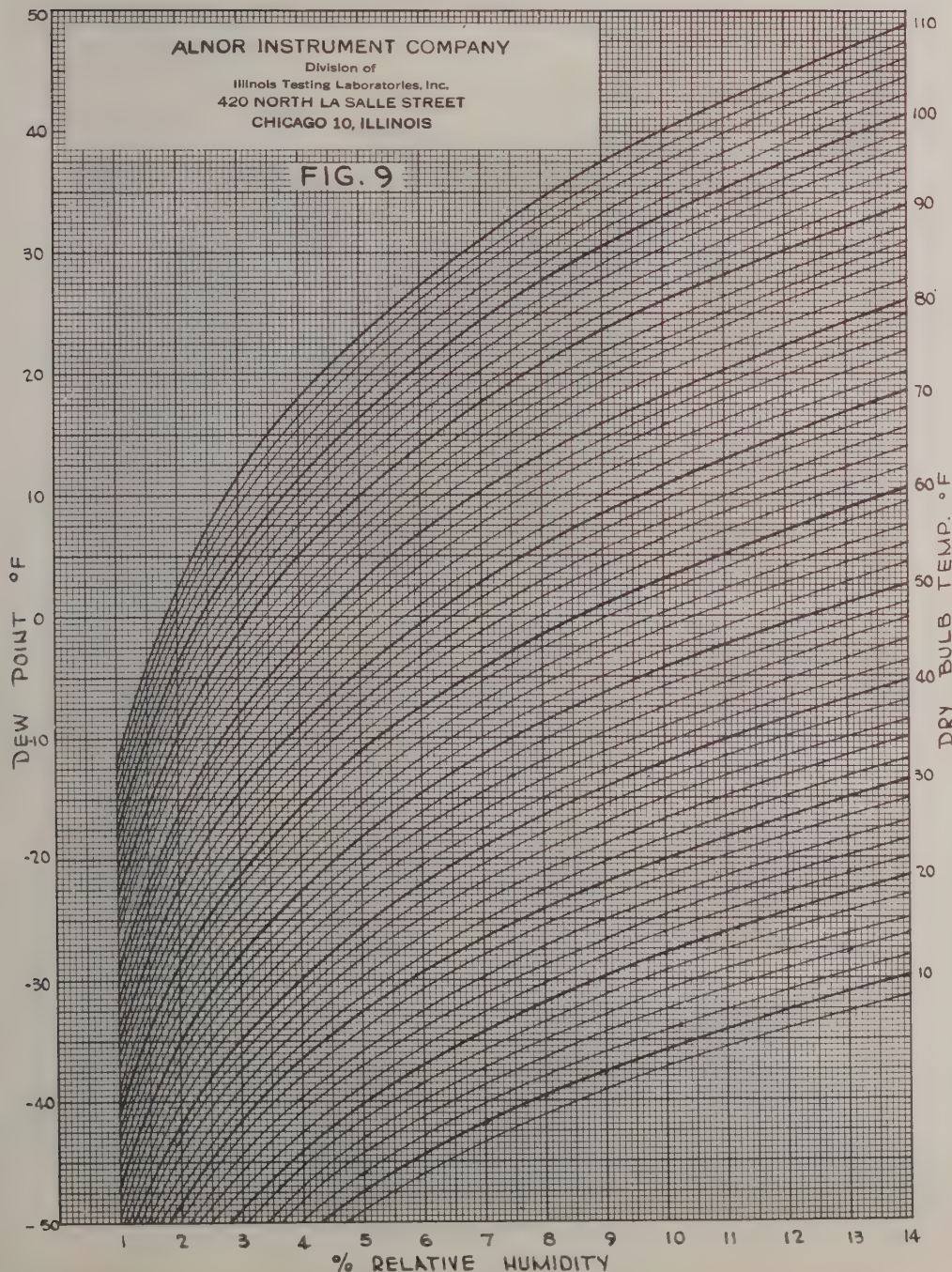


PSYCHROMETRIC CHART

ALNOR INSTRUMENT COMPANY

Division of
Illinois Testing Laboratories, Inc.
420 NORTH LA SALLE STREET
CHICAGO 10, ILLINOIS

FIG. 9



PSYCHROMETRIC CHART

ALNOR INSTRUMENT COMPANY

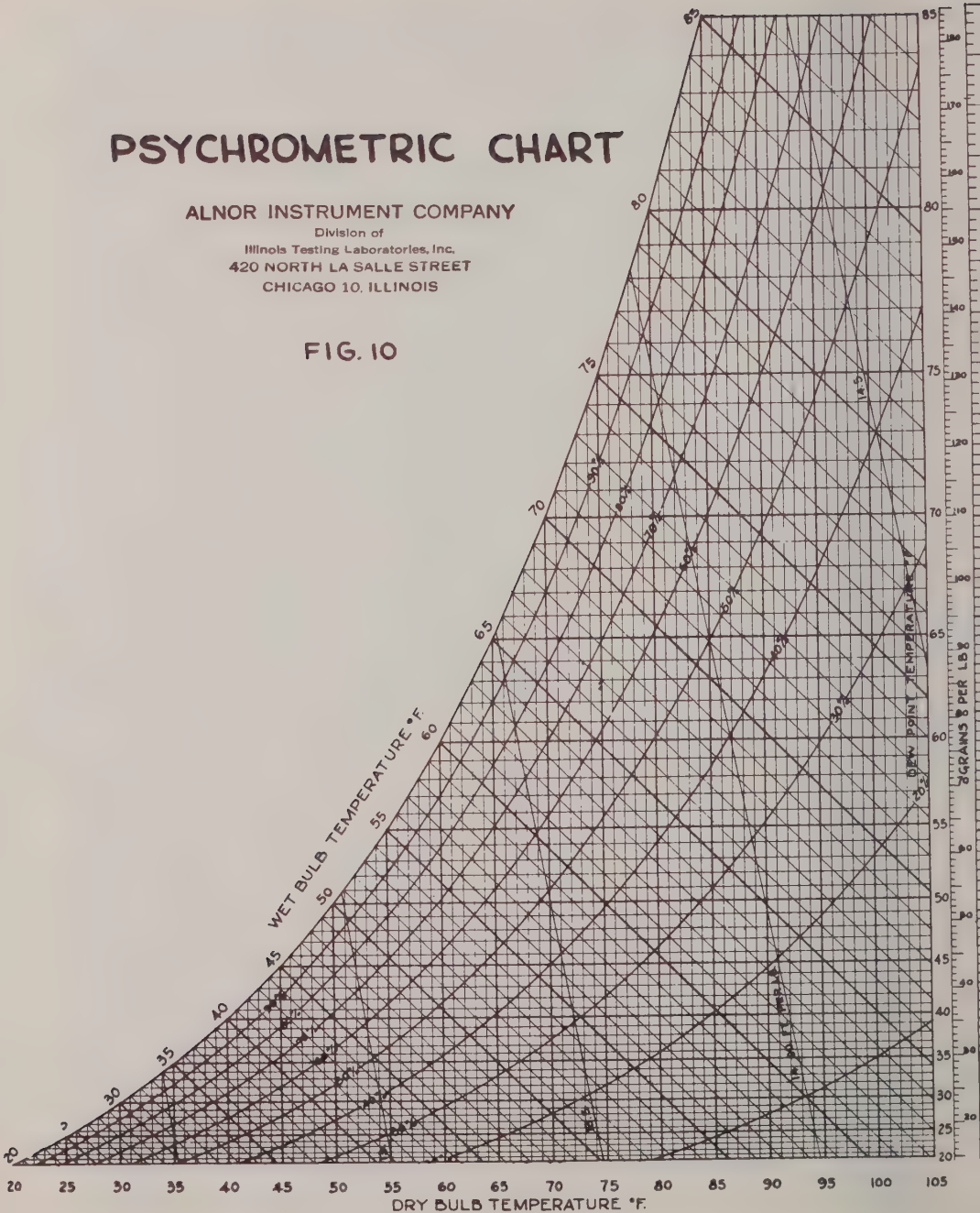
Division of

Illinois Testing Laboratories, Inc.

420 NORTH LA SALLE STREET

CHICAGO 10, ILLINOIS

FIG. 10



MAINTENANCE AND SERVICE NOTES

FOR

"ALNOR" DEW POINTERS

To operate satisfactorily, the "Alnor" Dew Pointer must be kept clean and lubricated frequently.

1. **Filter** – Check the filter (fiber glass) frequently and replace the filter material when necessary. This is very important. Fiber glass is inexpensive – use it freely. Be sure filter-screen is in place.
2. **Lubrication** – Keep the pump piston lubricated with a good grade of white petroleum (Vaseline). **Do not over-lubricate.** When working with hydrogen the pump piston must be lubricated more frequently.
3. **Bubbles in oil column** – Bubbles in the oil column of the pressure ratio gauge can easily be removed by alternately pumping up the instrument and releasing the pressure. Tilt the instrument forward or to the left during this operation because this will help remove the bubbles.
4. **Refilling Oil Well** – If the oil is accidentally blown out through the gauge valve (see paragraph No. 9, Ratio Gauge) additional oil can be added.
 - a. Be sure the purging valve is open, operating valve up (plunger pulled out) and there is no flow to the instrument.
 - b. Remove the knurled knob on the filling well and unscrew the needle screw. Use a small screw-driver to fit the filling well.
 - c. Place the unity adjuster in its mid position.
 - d. Tilt the instrument to the left.
 - e. Depress the gauge valve, **and at the same time** add oil by means of the eye dropper provided, until the column comes up to the 1.0 mark. Hold the dropper firmly in the filling well. Release the gauge valve before removing the dropper. Be sure that the needle screw is tightened in place before attempting to use the instrument.
 - f. The manometer oil supplied has a specific gravity of .834. Any other grade oil having approximately the same specific gravity can be used because the density of the oil is not a major factor in the calibration of the Pressure Ratio Gauge.
5. **Leaks** – To operate satisfactorily, the "Alnor" Dew Pointer must be free from leaks.
 - a. Check all connections. The purging valve can be reseated by tightening the needle point into the seat. Wear on the operating valve packing can be taken up by tightening the top cap. Check the fog chamber window and lens cap.
 - b. If after checking all connections and parts, the oil column in the pressure ratio gauge still should drop, the fault may be in the double acting pump.

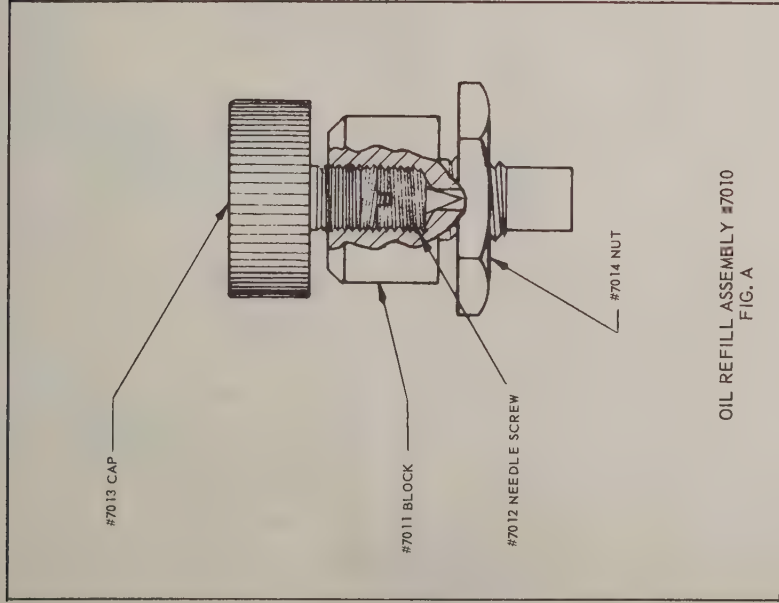
ALNOR INSTRUMENT COMPANY

DIV. OF ILLINOIS TESTING LABORATORIES, INC.

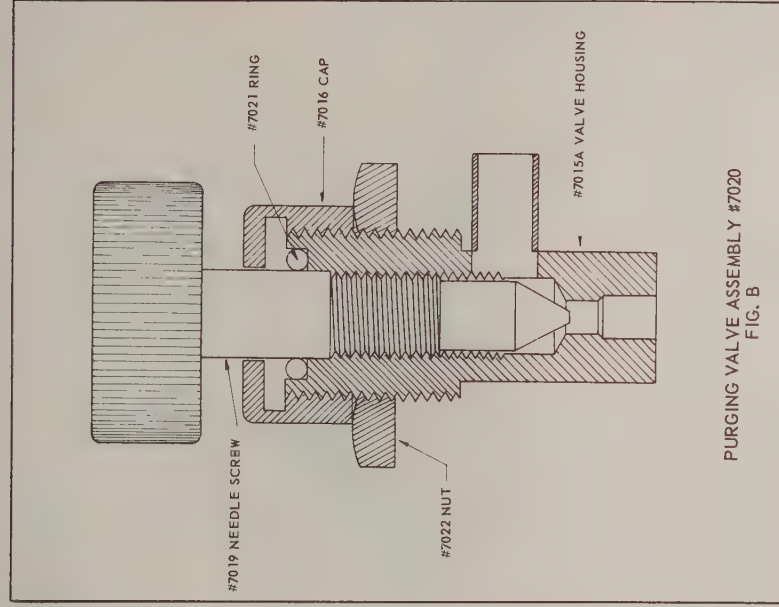
420 N. LaSalle Street

Chicago, Illinois 60610

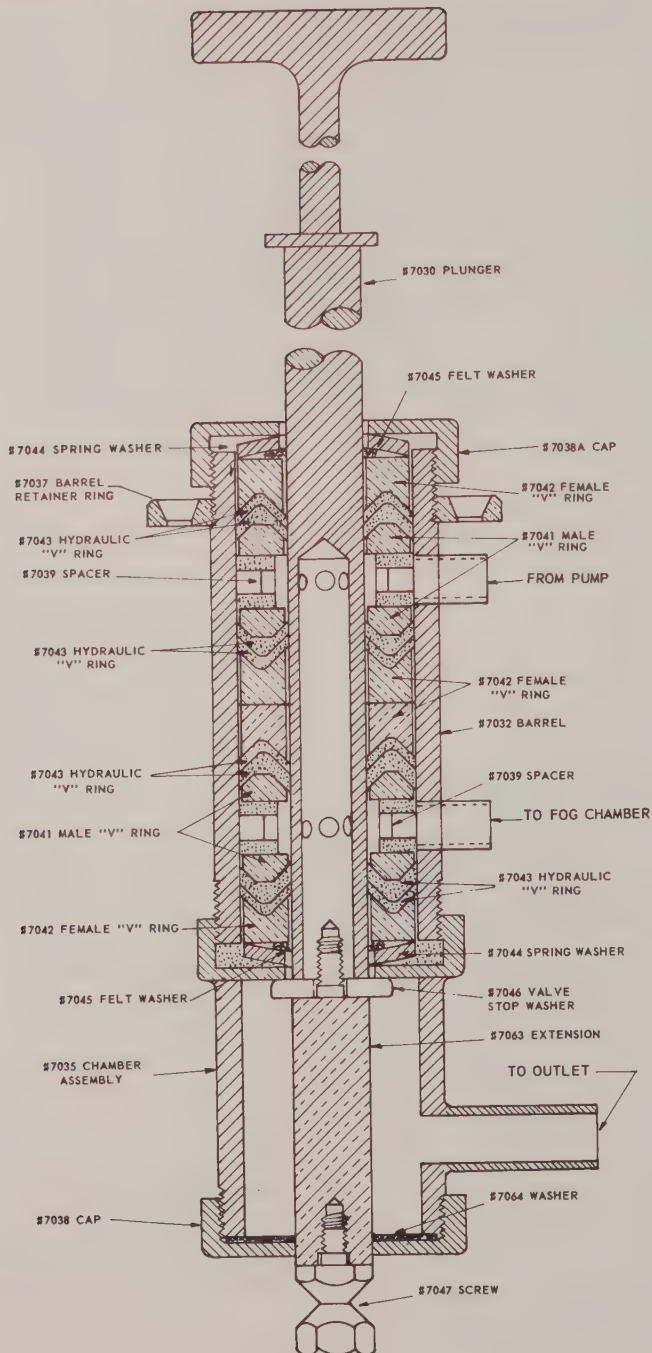
6. **Pump** – The pump is designed so no outside atmospheric pressure can interfere with the pump action and only the gas to be tested will go through.
 - a. The pump is provided with 4 valves (see fig. F). The inlet valve (from filter) and the outlet valve (to operating valve) are the main valves. If dirt or any other foreign particles accumulates in any one of these valves, the pump will not work properly.
 - b. To check inlet valve (valve from filter) set oil column to 1.0 mark. Pump 10 full strokes and the oil column should come above .45 mark. If it takes more than 12 full strokes, the diaphragm could be damaged (stretched) or the inlet valve could be faulty. Loosen nut, carefully bend tubing to one side, unscrew valve screw, remove rubber seat, plunger and spring and clean all parts. If any of these parts are damaged, they should be replaced. Placing the parts back again, be sure to follow figure F. The valve screw should be tight.
 - c. To check outlet valve (to operating valve) pump up the pressure to approximately .4 mark, observe the oil column, if there is a slow drop of the oil and after depressing the operating valve, even a faster drop, the fault will be in the outlet valve. Proceed in the same manner as on the inlet valve, when replacing the parts again, be sure to follow figure F.
 - d. Keep the pump piston and "O" ring lubricated, and if necessary replace "O" ring.
7. **Operating Valve** – The operating valve generally requires little maintenance aside from occasional tightening of the top cap. If it is necessary to disassemble the valve be sure to follow figure C carefully when reassembling. Lubricate all parts with petroleum jelly before reassembling.
8. **Fog Chamber** – Keep window and lens clean. If necessary replace gaskets. Should the fog chamber become dirty and corroded, the instrument should be sent to the manufacturer for general cleaning, repair and recalibration.
9. **Ratio Gauge** – If the oil is accidentally blown out through the gauge valve, the gauge valve should be washed with naphtha or alcohol. Remove manometer push button by using wrench. To unscrew manometer valve, use two small screw drivers and remove valve. When replacing the valve be sure the "O" ring is in place. Leaks at the unity-adjuster can be corrected by replacing the two "O" rings or the complete adjuster. See figure E. Because of the high coefficient of expansion of the manometer oil frequent readjustment to the 1.0 mark is quite normal if the temperature is changing.
10. **Reservoir** – If diaphragm is damaged (usually stretched) the oil column in the pressure ratio gauge will not come up to the right pressure and excessive pumping becomes necessary and the correct Dew Point can not be obtained. The diaphragm is a Mylar Film. This material is very tough and it is most improbable that a rupture will occur. However depressing the gauge valve when the instrument is under pressure, may stretch the diaphragm. This may also result from pumping when the operating plunger is depressed. If this happens the diaphragm must be replaced. In most of these cases, the instrument should be sent back to the manufacturer for cleaning and repair.



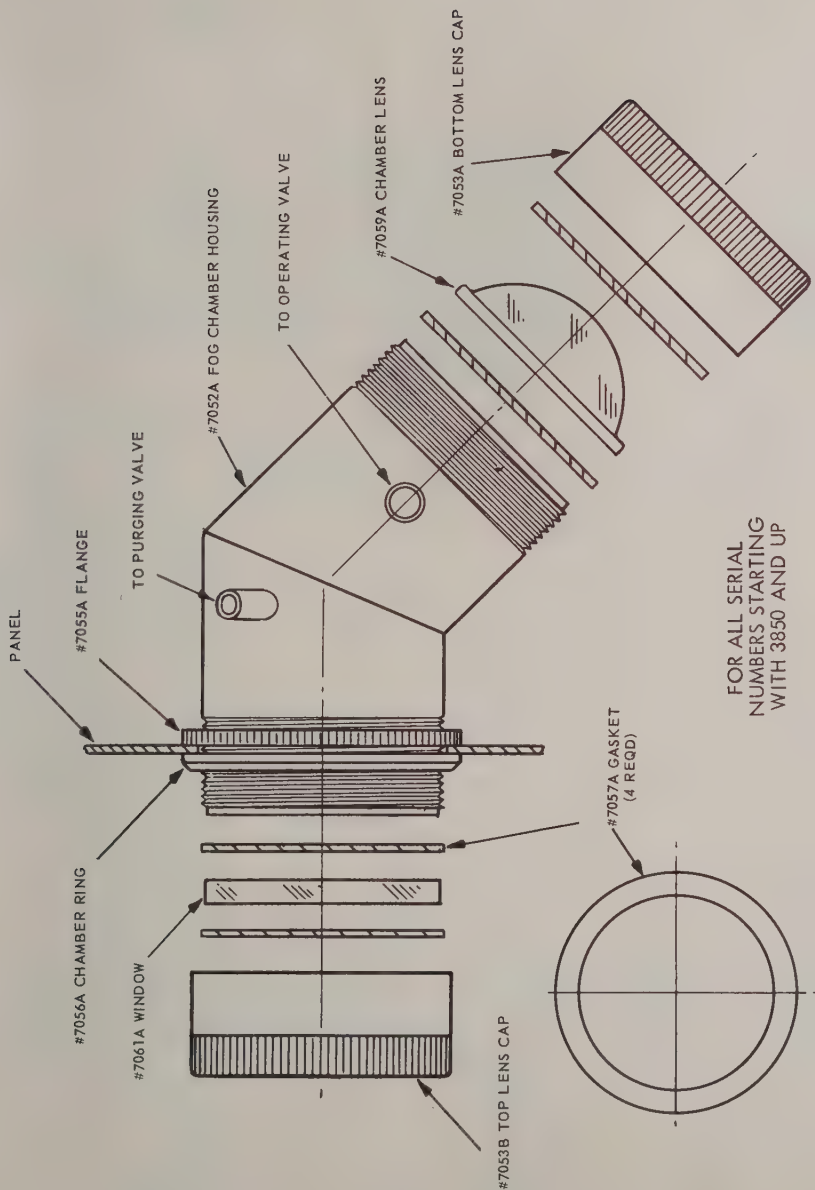
OIL REFILL ASSEMBLY #7010
FIG. A



PURGING VALVE ASSEMBLY #7020
FIG. B



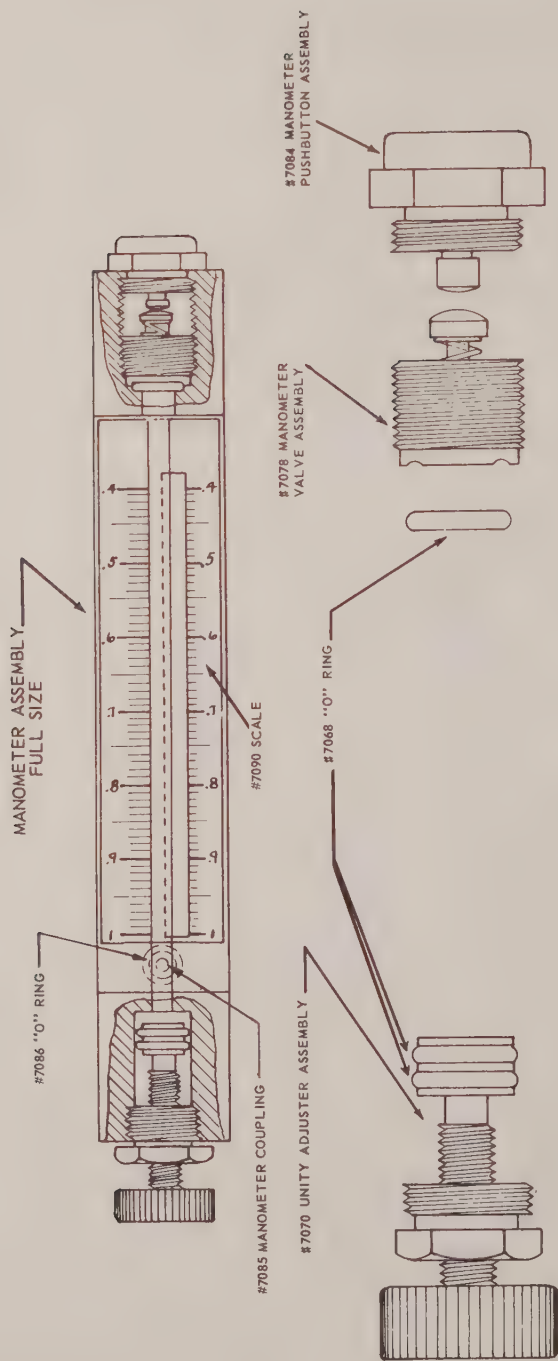
OPERATING VALVE ASSEMBLY #7040
(when ordering, specify type & serial no.)
FIG. C



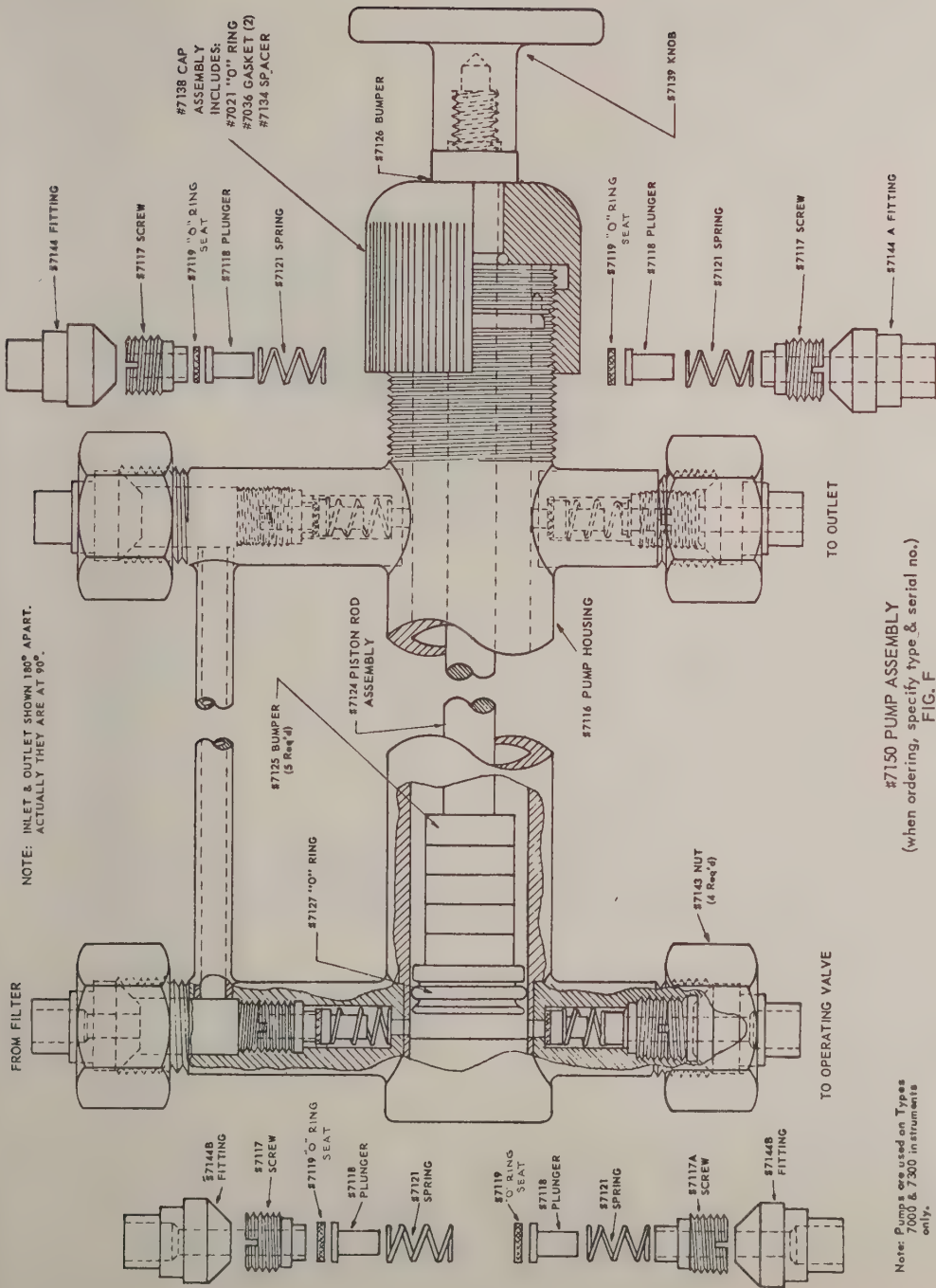
FOR ALL SERIAL
NUMBERS STARTING
WITH 3850 AND UP

FOG CHAMBER ASSEMBLY #7060A
(when ordering, specify type & serial no.)
FIG. D

NOTICE: FIG. D-1
APPLIES WHEN
SERIAL # IS 3850
OR HIGHER



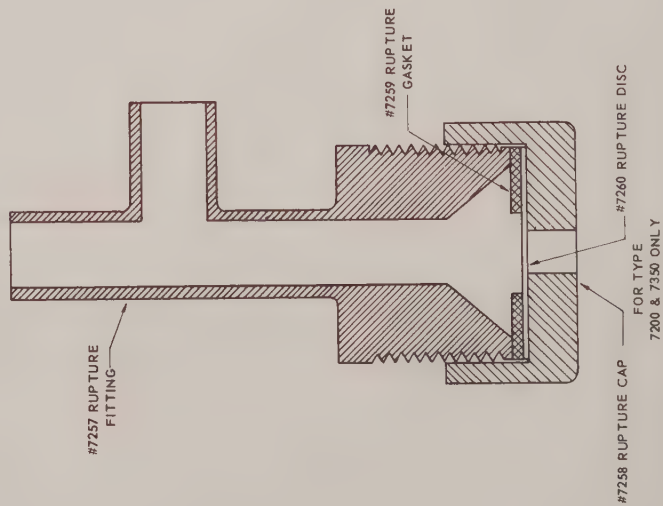
#7065 RATIO GAUGE ASSEMBLY
(when ordering, specify type & serial no. - h, u, or l)
DOUBLE SIZE
FIG. E



#7150 PUMP ASSEMBLY
(when ordering, specify type & serial no.)
FIG. F

Note: Pumps are used on Types 7000 & 7300 instruments only.

FIG. G
#7261 RUPTURE FITTING ASSEMBLY



#7266 INLET VALVE ASSEMBLY

FIG. H

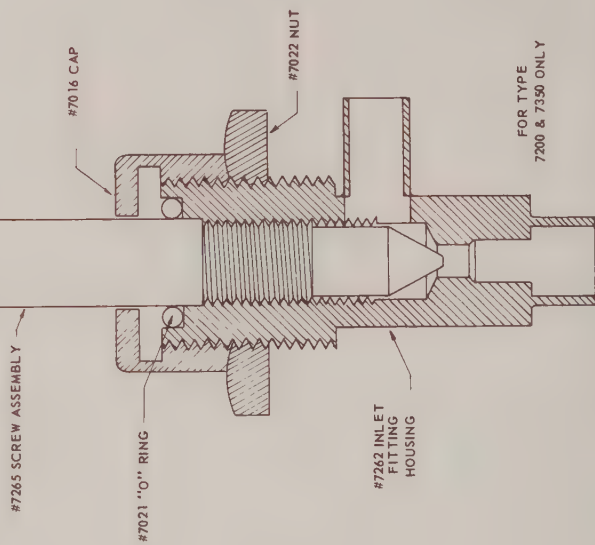
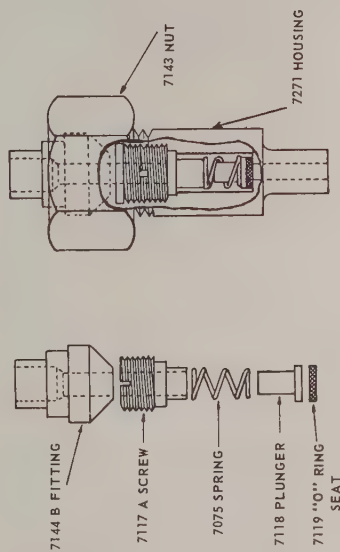


FIG. I



7270 AUTOMATIC RELIEF VALVE

FOR TYPE 7200 & 7350 ONLY

TROUBLE SHOOTING CHART

FOR

"ALNOR" DEW POINTER

OBSERVED DEFECT	PROBABLE FAULT	REMEDY
Oil drops in Pressure Ratio Gauge while under steady pressure	Leaks in system or Leak in pump outlet valve	See Paragraph 5 See Paragraph 6c
Oil rises in Pressure Ratio Gauge while under steady pressure	Leak in Pressure Ratio Gauge Valve	Replace Pressure Ratio Gauge Valve
Pump does not operate freely	Lack of Lubrication	Lubricate pump piston See Paragraph 2
Excessive pumping required	Restriction in supply to Dew Pointer or Diaphragm damaged	Remove Restriction See Paragraph 10
Oil must be replaced frequently	Leak at Unity adjuster	Replace "O" Rings on Unity Adjuster See Paragraph 9

Replace Filter Material Frequently.

PARTS LIST FOR

ALNOR DEW POINTERS,

TYPES 7000, 7200, 7300 AND 7350

ASSEMBLY OR PART NUMBER	DESCRIPTION	PRICE
7009	INLET FITTING	\$ 5.50
7010	OIL REFILL (See Figure A)	9.00
	7012 Needle screw only (for 7010)	1.00
	7013 Cap only (for 7010)	2.00
7020	PURGING VALVE (See Figure B)	15.00
	7016 Cap only (for 7020)	1.50
	7019 Needle screw only (for 7020)	5.00
	7021 'O' ring (for 7020) package of 6	3.00
7040	OPERATING VALVE (See Figure C)	60.00
	7030 Plunger	20.00
	7032 Valve Barrel	6.00
	7035 Chamber	6.00
	7036 Flange	1.50
	7037 Ring	2.00
	7038 Cap, plain	3.00
	7038-A Cap, plated	3.50
	7039 Spacer, package of 2	4.50
	7041 Male 'V' ring, package of 8	4.00
	7042 Female 'V' ring, package of 8	4.00
	7043 Hydraulic 'V' ring, package of 8	4.00
	7044 Spring Washer, package of 4	1.00
	7045 Felt Washer, package of 4	1.00
	7046 Stop washer	.50
	7047 Switch Screw	3.00
	7063 Extension	1.50
	7064 Gasket	.50
7060-A	FOG CHAMBER (See Figure D-1) for serial 3850 and higher	75.00
	7052-A Fog Chamber housing	50.00
	7053-A Bottom lens cap	5.00
	7053-B Top lens cap	6.00
	7055-A Flange	1.50
	7056-A Ring	2.00
	7057-A Gasket, package of 12	2.40
	7059-A Chamber lens	8.00
	7061-A Window	2.50

Minimum Charge — \$5.00 — f.o.b. Chicago, Illinois

ASSEMBLY OR PART NUMBER	DESCRIPTION	PRICE
7065	RATIO GAUGE ASSEMBLY (See Figure E)	60.00
	7062 Manometer block	35.00
	7068 'O' ring, package of 12	6.00
	7070 Unity Adjuster	6.00
	7084 Push Button Assembly	4.00
	7078 Manometer valve assembly	5.00
	7085 Manometer coupling	1.00
	7086 'O' ring, package of 12	6.00
	7092 Scale assembly	8.00
~~7100~~ 7101	RESERVOIR ASSEMBLY	25.00
	7096 Reservoir	10.00
	7098 Reservoir	10.00
	7099 Diaphragm, package of 6	5.00
7110	FILTER ASSEMBLY	9.00
	7104 Filter cap	2.00
	7105 Filter gasket	.25
	7106 Filter screen	.25
7150	PUMP ASSEMBLY (See Figure F)	75.00
	7116 Pump housing (including valves)	50.00
7120	SPARE PARTS GROUP FOR 7150	10.00
	3 - #7117 check valve screws	
	1 - 7117-A " " "	
	12 - #7118 check valve plungers	
	12 - 7119 " " seats	
	12 - 7121 " " springs	
	6 - 7127 piston 'O' rings	
	7124 piston rod assembly	5.00
	7125 Piston bumper, package of 10	1.00
	7126 piston bumper	.25
7138	PUMP CAP ASSEMBLY	10.00
	7136 Cap gasket, package of 6	1.00
	7021 'O' ring, package of 6	3.00
	7139 Pump knob	3.50
	7141 Pump flange	1.00
	7142 Pump ring	2.50
	7143 Fitting nut, package of 4	4.00
	7144 Pump fitting	1.00
	7144-A Pump fitting	1.00
	7144-B Pump fitting, package of 6	4.00

Minimum Charge - \$5.00 - f.o.b. Chicago, Illinois

ASSEMBLY OR PART NUMBER	DESCRIPTION	PRICE
	MISCELLANEOUS PARTS	
7151	Thermometer shield	5.00
7152	Thermometer base	1.50
7153	Thermometer protection tube	3.00
7154	Thermometer, 40° to 120°F	5.00
7176	Toggle switch, S.P.S.T.	1.50
7177	Toggle switch, D.P.D.T.	2.00
7199-A	Panel Wiring assembly for 7000, 7100 and 7200	35.00
7199-B	Case Wiring assembly for 7000, 7100 and 7200 (less 7220 cable assembly)	40.00
7190	Mercury Switch Assembly	8.00
7186	Switch spring assembly	3.00
7189	Mercury switch	5.00
7192	Hose nipple connector with 7143 nut	3.00
7193	Tubing nipple connector with 7143 nut	3.00
7203	Lamp arm bracket	1.00
7204	Lamp bracket	1.00
7205	Lamp socket	1.50
7206	6-8 volt lamp, package of 2	1.00
7207	lamp protection bracket	1.00
7210	Transformer	7.50
7211	Battery	4.00
7212	Battery male plug	.50
7213	battery bracket	1.50
7216	twist-lock base	2.50
7219	Plastic tubing (3 feet long)	1.50
7220	Connector Cable Assembly	5.00
7229	wrench	1.50
7230	calculator	2.75
7231	manometer oil (4 oz. plastic container)	5.00
7235	Filter fiber glass (1 box)	1.00
7202	Case for 7000 series (Specify Serial No.)	35.00

Minimum Charge — \$5.00 — f.o.b. Chicago, Illinois

ASSEMBLY OR PART NUMBER	DESCRIPTION	PRICE
ADDITIONAL PARTS FOR USE WITH TYPES 7200 and 7350		
7261	RUPTURE FITTING (See Figure G)	6.00
	7258 Rupture cap	1.50
	7259) Gasket and disc, package of 12 Each	5.00
	7260)	
7266	INLET VALVE (See Figure H)	17.00
	7265 Needle screw	6.00
	7016 cap	1.50
	7021 'O' ring, package of 6	3.00
	7268 Inlet valve ring	2.00
	7269 Inlet valve flange	1.50
7270	AUTOMATIC RELIEF VALVE (See Figure I)	15.00
	7271 Valve housing	5.00
	7119 Seat	.25
	7118 Plunger	.50
	7075 Spring	.50
	7117-A Valve Screw	1.00
	7144-B Fitting	1.50
	7143 nut	1.75
ADDITIONAL PARTS FOR USE WITH TYPES 7300 AND 7350		
	7305 Fog Chamber, Serial #5000 and higher	100.00
	7307 rheostat	3.00
	7309 Push button switch	3.00
	7310 Resistance thermometer	175.00
	7325 Pump (For type 7300)	75.00
	7116-A Pump housing	55.00
	7320 Ratio Gauge — Assembly	75.00
	7311 Manometer block	50.00
	7339 Scale Assembly	8.00
	7351 Case for 7300 series (Specify Serial No.)	50.00
		2.50

Instructions — Specify type and serial-number.

Minimum Charge — \$5.00 f.o.b. Chicago, Illinois

ALNOR INSTRUMENT COMPANY
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